not share in the hiccoughs. The diaphragm moved up very slightly with each inspiration.

December 26, the patient ceased to hiccough, but was very nervous.

December 31, there were no hiccoughs. The patient was much better.

January 5, 1931, the patient did not hiccough, but she had a severe cough with injected pharynx.

January 10, she was very nervous. Blood pressure was systolic 130, diastolic 100.

January 15, she was enjoying good health and was discharged without hiccoughs.

January 24, she was readmitted to the hospital, complaining of shortness of breath.

January 26, fluoroscopic examination showed the heart of average size. It had certainly not increased in size perceptibly since the last observation. The diaphragm was high on each side. The respiration was very rapid and forced inspiration seemed impossible. The diaphragm was undergoing short, rapid excursions synchronous with the movements of the abdomen. The thoracic movement was so rapid as to deny positive identification of expiratory efforts.

February 1, the patient was resting quietly with slight increase in respiration.

February 5, the patient was feeling well and was discharged as cured.

August 1, 1931, eight months after the operation, I requested the patient to see me, at which time she maintained a normal weight, had a normal blood pressure with a slight increase in pulse and respiration. Let me quote her own words: "I am feeling better than ever, enjoying good health, and doing all my house work."

August 22, fluoroscopy of the chest showed complete paralysis of the left diaphragm with no excursion on deep inspiration. The left diaphragm sagged into the chest with the patient in the Trendelenburg position. The right diaphragm occupied a normal position, excursion was free, the heart was of average size, and the pulsation rapid.

The operation shows:

(1) The procedure is adaptable to uncomplicated cases of hiccoughs.

(2) Ample inspiration and expiration can be carried on after severance of the phrenic nerves.

(3) The shallow hiccoughs present after phrenicectomy soon subsided.

(4) There are changes in the position of the diaphragm before and after operation.

(5) There is early return to normal of the cardiovascular system.

(6) There is return of function to the right diaphragm seven months after operation.

REFERENCES

Guerra: Kanalliche Sworchtrennung bei schweren chronischen Schluckkrämpfen. Lungenerkrankungen. Deutsche Med. Wchnschr., 2:2220-2211.

Sauerbruch, quoted by Krab, H.: Munchen. Med. Wchnschr., 69: 807-811, 1922.

VARIOUS USES OF ELECTROSURGERY IN THE TREATMENT OF BRAIN TUMORS*

By Ernest Sachs, M.D.,
St. Louis, Mo.

Electrosurgery was first tried and introduced into surgery by Kelly about six years ago. When his article appeared, I secured one of the machines then on the market and tried it upon some animals in the laboratory in experiments upon the brain. I abandoned it, however, as I found: (1) that it produced convulsive movements; (2) though it stopped the bleeding of cortical vessels, these were so delicate and friable that they tore very readily. It was only after Cushing's publication in 1928, in which he reported his results with the apparatus devised by Bovie, that I again began to use it. Since April, 1928, I have been using this method, and have found it such an essential and invaluable part of my armamentarium that I will not undertake a cranial operation today unless I have the apparatus at my side.

I do not know enough about electricity to discuss this phase of the subject at any length. There are different types of high frequency current, which are known as damped and undamped currents. The waves of the damped current (*Fig. 1*) vary both in rate and amplitude, while the undamped current (*Fig. 2*) has both a uniform rate and amplitude. This latter type of current, undamped, has the cutting property but, as it does not dehydrate, it lacks the coagulating power which is the essential feature we need. By combining the two types of current and producing a moderately damped wave (*Fig. 3*) or highly damped wave (*Fig. 4*), both the cutting and coagulating features are combined.

Another important feature in using the high frequency current is that the current used must have such a high rate of interruptions that it will not stimulate the nerve cells in the brain and give rise to convulsive seizures, either local or general.

The type of apparatus devised by Bovie delivers currents with these features.

I have visited a number of neurosurgical clinics which had such an electrical unit, but the

---

*Read in Section on Neurology and Psychiatry, Southern Medical Association, Twenty-Fifth Annual Meeting, New Orleans, Louisiana, November 18-20, 1931.

*Editor's Note.—Since more than the maximum number of illustrations furnished by the Journal appear in this paper, the cost for the extra illustrations is borne by the essayist.

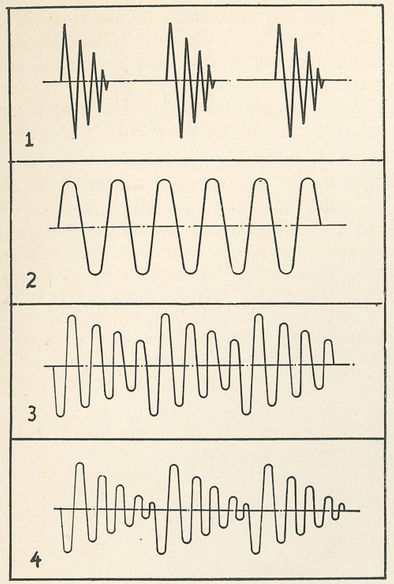

Fig. 1

Damped current showing highly damped waves which have very little cutting power, but marked coagulation and dehydration qualities.

Fig. 2

Undamped current. Cutting current, but no dehydration effect.

Fig. 3

Moderately damped current. As in this type the damped qualities are only moderate, the current cuts more than it dehydrates.

Fig. 4

Markedly damped current. This type of current has both cutting and coagulation features.

apparatus stands in a corner unused, and when I have asked why they do not use it, the answer invariably has been, "It does not work." It takes time to learn any new technical method. Fully six months of almost daily use were required before I learned the possibilities of electrosurgery and how to use it effectively. Today, it is in constant use during an operation after the skin incision has been made with a scalpel. No skin incisions on the head should be made with the current, for, if one uses enough coagulation to stop bleeding from the scalp, the wound will not heal by primary union, and without coagulation the incision can be better made with a knife.

When we first began using this method, the power was turned on by a trigger, attached to the pencil held in the operator's hand. That was found impractical and now the current is turned on or off with a foot switch controlled by an assistant. Two sterile handles have been attached to the machine so that the same assistant can instantly switch the current to and fro from coagulation to cutting (*Fig. 5*).

Kelly, in his original article, pointed out that running a current down a clamp on a vessel that had been cut, coagulated it, so that it did not need to be tied. When one grasps a vessel on the cortex of the brain, even with a very delicate forceps, and coagulates it, the coagulated vessel is very likely to stick to the forceps and when the forceps is removed the vessel tears. It took a long time to overcome this difficulty, but we have solved it and the method we now employ constitutes, I believe, one of the most valuable uses of electrosurgery. The vessel is coagulated before it is cut and it is not grasped at all with an instrument. The vessel is stroked. A small vessel is instantly shriveled up, but a larger vessel only gradually contracts and finally becomes obliterated. To accomplish this, it is very important not to use too strong a current, for, if the current is too strong, the vessel is perforated, and, if it is a large one, a very severe hemorrhage follows. By the proper application of this technic, vessels 3 to 4 mm. in diameter and even larger have been occluded, but it may take several minutes to do this (*Fig. 6*).

Formerly our most effective method, in fact, our only method of occluding vessels in the brain was by means of Cushing silver clips. Today we rarely use one and carry many operations through without the use of a single clip. Formerly it was not uncommon to use from 50 to 100 clips (*Figs. 7, 8, 9* and *10*). Small bleeding points on the dura used to take an endless time to stop. Often to stop these bleeders we applied bits of muscle, but today that is no longer needed. It can all be done with the current (*Figs. 11, 12* and *13*).

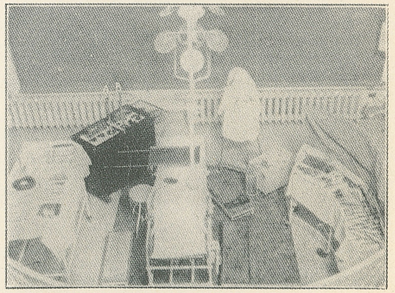

Fig. 5

The Bovie unit is part of the operating room "set up." The long handles (A and B) are sterile and can be manipulated by an assistant.

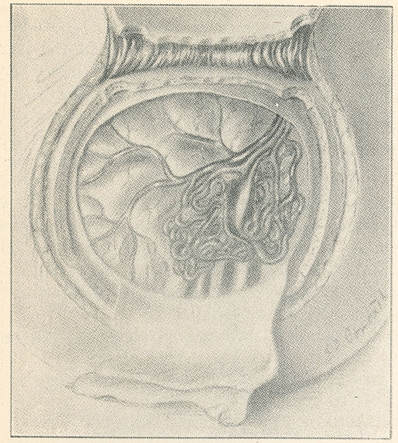

Fig. 6

This is a drawing of the first arteriovenous aneurysm we removed with electrosurgery. One of the largest vessels ruptured because too strong a current was used. The hemorrhage was controlled with a large piece of muscle. Patient made an uneventful recovery. Operation, January, 1929.

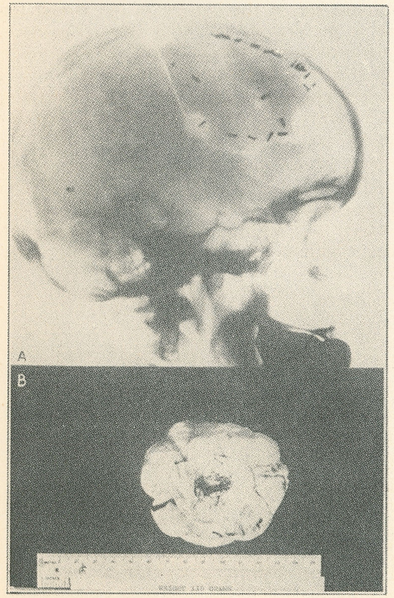

Fig. 7

A. Appearance in the x-ray plate of the operative field after removal of a meningioma. Note the large number of silver clips that were used before the days of electrosurgery. B. The tumor, showing its dural attachment.

Angiomas or arteriovenous angiomas of the cortex, which formerly we left severely alone and never dared to touch, can be shriveled with this method, but let me emphasize that it is not a time-saving device, for coagulating such large vessels is tedious and must be done slowly (*Figs. 14, 15* and *16*). The middle meningeal artery in an operation for trigeminal neuralgia we used to control by plugging the foramen spinosum or by tying: now we usually coagulate it before cutting

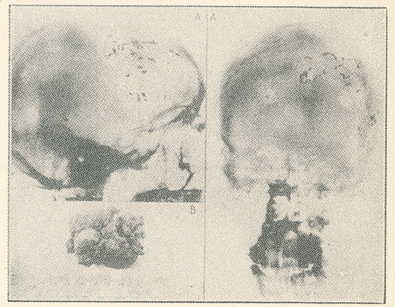

Fig. 8

A. Appearance in the x-ray plate of the operative field after removal of a meningioma attached to the falx. B. Meningioma removed.

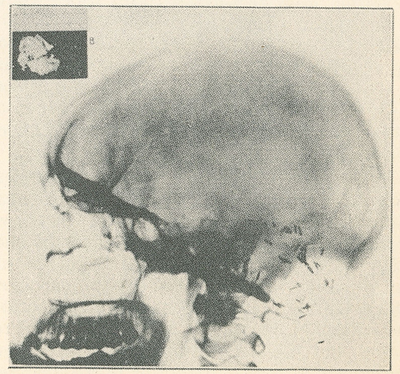

Fig. 9

Appearance of postoperative field from which an astrocytoma had been removed. The bulk of the tumor was cystic; the nubbin (B) was rather small.

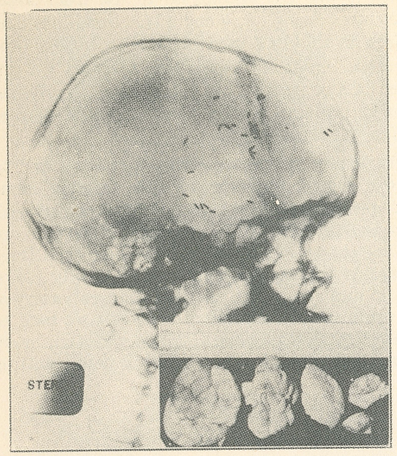

Fig. 10
Ependymoma removed from a young child. It was a well encapsulated tumor, but a great many clips had to be used to control the vessels.

it. When removing a tumor, the vessels around the line of incision are coagulated. Sometimes, of course, vessels are cut and have to be grasped and coagulated, and then one may have the difficulty that the vessel sticks to the forceps. One of the most difficult problems we still have to deal with is the removal of the malignant gliomas, the type known as spongioblastoma multiforme. In their removal one of the problems has been that it has been very difficult, often impossible, after incising the cortex with a knife, to distinguish tumor tissue from normal brain tissue. An incision with the electric knife does not change the gross appearance of brain tissue so that one can recognize the limits of a tumor. With this technic we stand a better chance of radically removing this type of tumor than ever before (*Fig. 17*).

In the past year we have used electrosurgical technic for still another condition. In communicating hydrocephalus I still believe the most promising procedure is the removal of the choroid plexus. The anatomy of the choroid plexus varies greatly. In some cases it is pedunculated with a narrow base and one clip or tie controls the entire blood supply and it is readily removed; but in the great majority of cases there are numerous vessels, twenty or thirty, that run into it from the surface of the thalamus. Such plexuses I speak of as sessile. To tie these vessels or clip them was a formidable procedure and I have lost a number of cases in the past because of hemorrhage from one of them. By running the coagulating current into the plexus without grasping it, the plexus can be readily shriveled and destroyed. At first I feared the heat might give us a thalamic disturbance, but that has not been the case. The coagulated, sometimes slightly charred, plexus is left *in situ*. It has been claimed that leaving slightly charred tissue in a wound is harmful, but I have not found that to be the case, and such carbonized tissue is far less dangerous than traumatized, devitalized brain tissue.

Electrosurgery may also be used to core out

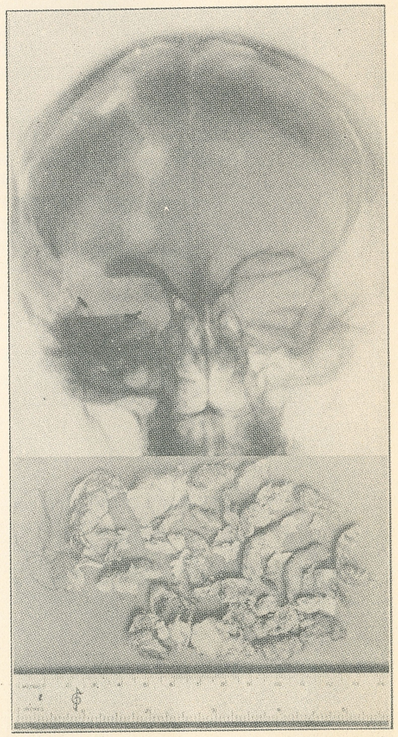

Fig. 11
Meningeal fibroblastoma (40 grams) removed with the electric knife. The tumor grew from the olfactory groove, had grown through the roof of the orbit, and was partly intraorbital. In this case, three or four clips were used in the olfactory groove, but today this probably would not be necessary, as the technic in handling these tumors has improved.

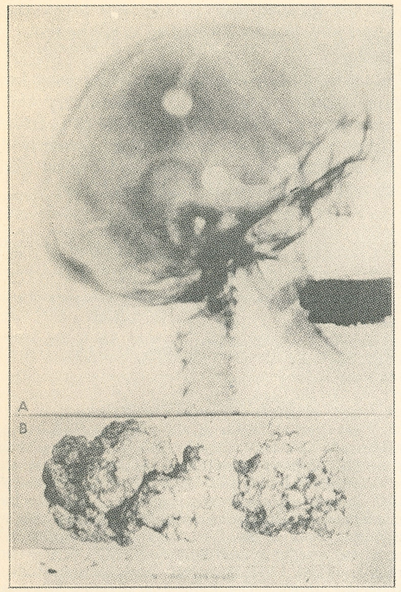

Fig. 12
A. Appearance of operative field after removal of meningioma with electrosurgical technic. This tumor lay on the floor of the middle fossa and was attached to the greater wing of the sphenoid. The base was very broad and huge vessels ran into the tumor. Only one clip was used throughout the operation and this one proved unnecessary, as the vessel was coagulated. B. Tumor removed piece-meal, cored out with loop.

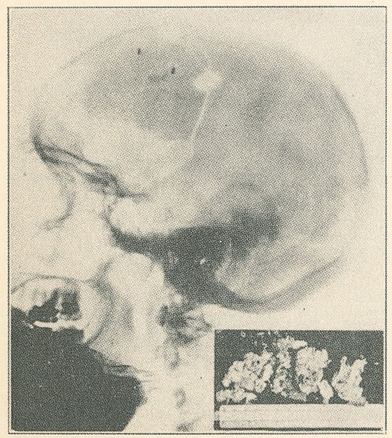

Fig. 13
An oligodendroglioma lying along the falx and extending down to the ventricle. Very vascular. Only two clips had to be used in the entire procedure.

the center of large tumors, such as meningiomas, and collapsing them, leaving a shell or capsule (*Fig. 11*). In this way large tumors may be removed through smaller openings without compressing the surrounding brain tissue so much as was necessary if the entire tumor were removed in one mass. This use of electrosurgery was particularly emphasized by Cushing in his early paper on the subject and, though it is invaluable, I have found the other uses even greater.

One of the questions that has been asked repeatedly is: "Does not secondary hemorrhage occur much more frequently with electrosurgery?"

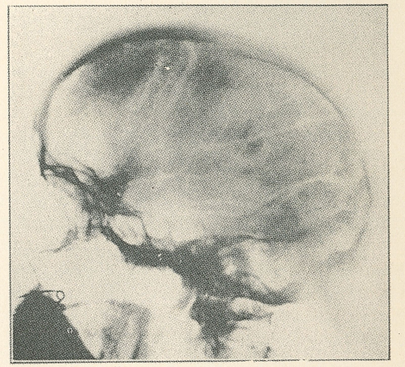

Fig. 14
X-ray appearance of arteriovenous aneurysm. The tortuous, partially calcified vessels can be clearly seen.

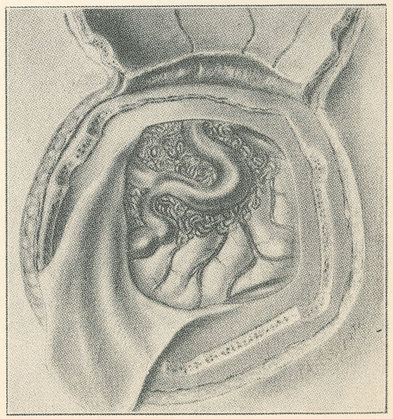

Fig. 15
Drawing of arteriovenous aneurysm seen in x-ray plate in Fig. 14.

I have used the method now for over three years in several hundred cases and I am confident that it does not. There are tricks in every trade. When a large vessel is coagulated it must be shriveled for quite a distance, 4 or 5 mm. at least, otherwise the plug might be blown out.

Fig. 16
X-ray film after operation showing that no silver clips were used throughout this procedure.

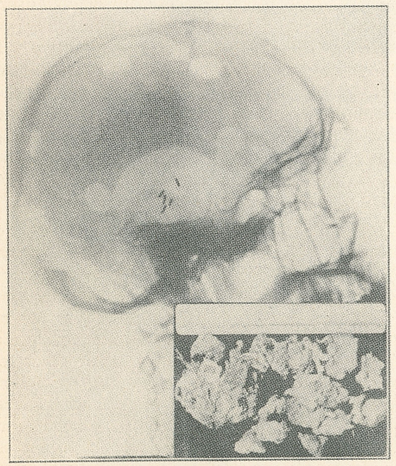

Fig. 17
Very vascular subcortical spongioblastoma multiforme. Weight 87 grams. Formerly there would have been countless silver clips used, while today the few clips shown in the picture could probably have been dispensed with and the vessels might have been controlled if a spraying current had been used.

There are many other details of using this method which can be learned only at the operating table.

Electrosurgery, in my opinion, is the most important technical advance in neurosurgery that we have had in years. It has made it possible to attack and remove tumors that formerly I would not have dared attempt to remove, and it has made all removals of tumors easier.

REFERENCES

1. Cushing, Harvey: Electrosurgery as an Aid to the Removal of Intracranial Tumors. With a Preliminary Note on a New Surgical Current Generator by W. T. Bovie, Ph.D. Surg., Gyn. & Obst., 47: Dec., 1928.
2. Olivecrona, H.: Ueber die Anwendung der Elektrokoagulation bei Gehirntumoren. Munchener med. Woch. Stockholm, Sweden: nr 6 und 7, 1930.
3. Sachs, Ernest: Electrosurgical Unit as an Aid to the Neurologic Surgeon. Surg., Gyn. & Obst., 52:505-07. Feb. 15 (No. 2A), 1931.

DISCUSSION (*Abstract*)

Dr. J. G. Lyerly, Richmond, Va.—My experience with electrosurgery has been slightly less encouraging than that of Dr. Sachs, probably due to the fact that we have made more limited use of it. For certain encapsulated tumors on the surface of the brain, as the meningioma, with its attachment in the region of the longitudinal sinus, it has been used only in sealing off some of the smaller superficial vessels. The deeper and more inaccessible bleeding points have been controlled with muscle grafts. The infiltrating tumors, however, such as spongioblastomas, unless they are too vascular, can be more completely removed by cutting out bits of tumor with the electric loop. There is no doubt that we are obtaining better results now than we did in the beginning, probably from added experience in its use.

Dr. Temple Fay, Philadelphia, Pa.—Dr. Sachs has emphasized an important adjunct to our methods of attack upon cerebral tumors. His suggestion of coagulation of the large veins by repeated stroking is important.

In my experience the use of the loop for taking out tumors with a cutting current has not been so satisfactory as the removal of the tumor mass by suction. The vascular tree may be carefully isolated by suction, so that irregular extension of the tumor tissue along these paths into normal brain substance may be detected and removed. The electrocauterization of any suspected areas should follow and this combined method has given very satisfactory results. The loop method, when dealing with gliomata, frequently cuts away normal and diseased brain, at the same time making the line of demarcation difficult to follow.

Dr. Edgar F. Fincher, Jr., Atlanta, Ga.—In the treatment of Jacksonian epilepsy in which the lesion is only demonstrable after stimulating the epileptic zone, it has been our practice to destroy this cortical area by the injection of alcohol. The injection of alcohol into the cortex brings the danger of subsequent scar formation, and for this reason electrocoagulation of the cortex has been substituted. Coagulation brings about deeper destruction than was possible with alcohol and our results to date have been more satisfactory.

Another use of the electrosurgical unit has been in the treatment of brain abscesses. After turning down a bone flap, anticipating a cerebral neoplasm, the introduction of a brain cannula may prove the lesion to be an abscess. Using the coagulating bulb, the dura may then be sealed to the arachnoid and subsequently to the underlying cortex. Thus artificial adhesions are immediately produced, which permit opening the abscess without infecting the remaining tissue. We have treated 3 such cases in this manner successfully.

Dr. Sachs (closing).—Regarding Dr. Lyerly's question: in tumors that lie along the longitudinal sinus I have found electric coagulation of great value. Where there are numerous veins running into the sinus, as one encounters in the supratentorial approach to a cerebellar lesion over the occipital lobe, a great deal of time is saved by coagulating each vein before cutting it. Sometimes there are as many as twenty veins running from the occipital lobe into the sinus, and to tie these doubly or clip them, as we used to do, is not nearly so satisfactory as the method we now use.

Regarding Dr. Fay's point, of course I do not want to be understood as having given up all other technical methods for electric coagulation. Suction has been an essential part of our technic for at least the last five years, and occasionally we still are obliged to resort to a silver clip. At times, in a difficult case, every trick that a surgeon knows may be called into use. Electric coagulation has made it possible to remove tumors which it was impossible to remove by the older methods.

The case was mentioned in which a silver clip slipped down the canal several years after a cerebellar tumor had been removed. It is amusing in retrospect, but at the time it caused me much worry, since it might have made a fine basis for a damage suit. At that time one neurosurgeon who heard of my experience carried out some experiments to try to invent an invisible clip.

Dr. Fincher's point of using electric coagulation for focal epilepsy is very interesting. I have never tried it, but I certainly shall since he reports such good results. In the past I have always done a subpial resection of the cortex in focal epilepsies.

TREATMENT OF LUNG ABSCESS BY BRONCHOSCOPIC DRAINAGE*

By Harold Leslie Kearney, M.D.
New Orleans, La.

In this brief discussion I wish to mention the most salient features of lung abscess.

The lungs have a peculiar power of ridding themselves of atmospheric dust and of pathological secretions by the defensive mechanism of cough and ciliary wafting. Cough serves not only to carry foreign material out by the blast of air, but by the compression of the lung and physiologic narrowing of the bronchi which take place during expiration, actually squeezes up material from the deeper bronchi and the spongy-like lung. The cilia of the ciliated epithelium lining the tracheobronchial tree are continually wafting upward and assist in keeping the lungs free of dust particles from above and excessive secretions from below.

Chevalier Jackson has expressed the opinion that the fundamental factor in all pathologic conditions of the lung is impairment of the defensive power of the lung due to impairment of drainage and aeration. Failure of either the cough reflex or the ciliary action is an important factor in the etiology of suppurative disease of the lung.

In lung abscess there is a single focus or sometimes multiple foci of suppuration within the lung. This condition may affect any lobe of either lung. It may be centrally located and communicate with a bronchus. It may be peripherally located in proximity to the pleura, where it has little chance of adequate drainage through the bronchial tree and an excellent opportunity of rupturing into the pleural sac and complicating the condition with an empyema. In general, the first type of case is most favorably situated and the second type of case is least favorably situated for bronchoscopic drainage.

It has been variously estimated that from 10 to 25 per cent of cases of lung abscess heal spontaneously, due to this mechanism of cough and ciliary wafting assisting the natural defensive forces in their fight against the infection. In other cases cough and ciliary wafting are not sufficient to free the lung of the products of inflammation and 50 to 70 per cent of untreated cases of lung abscess die. A variable percentage of cases will be cured by any of the methods of treatment and a certain number of cases will die despite all treatment.

In lung abscess the treatment may be surgical, postural or by bronchoscopic drainage. Probably the great majority of lung abscesses are curable by bronchoscopic drainage if the treatment is instituted early. A lung abscess that has existed for eight weeks may be considered chronic. We have no means of knowing which cases will heal spontaneously and are no safer in following expectant treatment in abscess of the lung than in acute appendicitis. The earlier bronchoscopic treatment is instituted in lung abscess the more favorable will be the outlook.

Bronchoscopic drainage, done under local anesthesia, is advisable: (1) in acute abscesses which do not drain promptly and become quickly afebrile with posture; (2) in cases in which the

*Read in General Clinical Session, Southern Medical Association, Twenty-Fifth Annual Meeting, New Orleans, Louisiana, November 18-20, 1931.

not share in the hiccoughs. The diaphragm moved up very slightly with each inspiration.

December 26, the patient ceased to hiccough, but was very nervous.

December 31, there were no hiccoughs. The patient was much better.

January 5, 1931, the patient did not hiccough, but she had a severe cough with injected pharynx.

January 10 she was very nervous. Blood pressure was systolic 130, diastolic 100.

January 19, she was enjoying good health and was discharged without hiccoughs.

January 24 she was readmitted to the hospital, complaining of shortness of breath.

January 26, fluoroscopic examination showed the heart of average size. It had certainly not increased in size perceptibly since the last observation. The diaphragm was high on each side. The respiration was very rapid and forced inspiration seemed impossible. The diaphragm was undergoing short, rapid excursions synchronous with the movements of the abdomen. The thoracic movement was so rapid as to deny positive identification of expiratory efforts.

February 1, the patient was resting quietly with slight increase in respiration.

February 5, the patient was feeling well and was discharged as cured.

August 1, 1931, eight months after the operation, I requested the patient to see me, at which time she maintained a normal weight, had a normal blood pressure with a slight increase in pulse and respiration. Let me quote her own words: "I am feeling better than ever, enjoying good health, and doing all my house work."

August 12, fluoroscopy of the chest showed complete paralysis of the left diaphragm with no excursion on deep inspiration. The left diaphragm sagged into the chest with the patient in the Trendelenburg position. The right diaphragm occupied a normal position, excursion was free, the heart was of average size, and the pulsation rapid.

The operation shows:

(1) The procedure is adaptable to uncomplicated cases of hiccoughs.

(2) Ample inspiration and expiration can be carried on after severance of the phrenic nerves.

(3) The shallow hiccoughs present after phrenicectomy soon subsided.

(4) There are changes in the position of the diaphragm before and after operation.

(5) There is early return to normal of the cardiovascular system.

(6) There is return of function to the right diaphragm seven months after operation.

REFERENCES

Ruetz. Klassische sworchtellabrung bei schweren chronischen Schluckbeschwerden. Langenbeck's Archiven. Deutsche Med. Wchnschr., 57:734, 1931.

Sauerbruch, quoted by Kraus II. Munchen. Med. Wchnschr., 69: 807-811, 1922.

VARIOUS USES OF ELECTROSURGERY IN THE TREATMENT OF BRAIN TUMORS*

By Ernest Sachs, M.D.,
St. Louis, Mo.

Electrosurgery was first tried and introduced into surgery by Kelly about six years ago. When his article appeared, I secured one of the machines then on the market and tried it upon some animals in the laboratory in experiments upon the brain. I abandoned it, however, as I found: (1) that it produced convulsive movements; (2) though it stopped the bleeding of cortical vessels, these were so delicate and friable that they tore very readily. It was only after Cushing's publication in 1928, in which he reported his results with the apparatus devised by Bovie, that I again began to use it. Since April, 1928, I have been using this method, and have found it such an essential and invaluable part of my armamentarium that I will not undertake a cranial operation today unless I have the apparatus at my side.

I do not know enough about electricity to discuss this phase of the subject at any length. There are different types of high frequency current, which are known as damped and undamped currents. The waves of the damped current (*Fig. 1*) vary both in rate and amplitude, while the undamped current (*Fig. 2*) has both a uniform rate and amplitude. This latter type of current, undamped, has the cutting property but, as it does not dehydrate, it lacks the coagulating power which is the essential feature we need. By combining the two types of current and producing a moderately damped wave (*Fig. 3*) or highly damped wave (*Fig. 4*), both the cutting and coagulating features are combined.

Another important feature in using the high frequency current is that the current used must have such a high rate of interruptions that it will not stimulate the nerve cells in the brain and give rise to convulsive seizures, either local or general.

The type of apparatus devised by Bovie delivers currents with these features.

I have visited a number of neurosurgical clinics which had such an electrical unit, but the

*Read in Section on Neurology and Psychiatry, Southern Medical Association, Twenty-Fifth Annual Meeting, New Orleans, Louisiana, November 18-20, 1931.

*Editor's Note.—Since more than the maximum number of illustrations furnished by the Journal appear in this paper, the cost for the extra illustrations is borne by the essayist.